

Application Number 10/670,944
Response to Office Action mailed January 10, 2008

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AMENDMENTS TO THE CLAIMS

This listing of claims will replace all prior versions and listings of claims in the application.

Listing of Claims:

Claim 1 (Currently Amended) A method comprising:
calculating traffic statistics associated with packet flows through a network;
storing the traffic statistics within a flow table;
maintaining a heap that provides a heap-ordered representation of at least a portion of the traffic statistics of the packet flows within the flow table, wherein the heap is a tree having a root node and a plurality of other nodes arranged as parent nodes and child nodes, each of the nodes storing traffic statistics for a different one of the packet flows, and wherein the tree is heap-ordered in that a value for the traffic statistics stored in any child node of the tree is less than or equal to a value for the traffic statistics stored within that child node's parent node within the tree;
processing the heap to select one or more of the packet flows; and
outputting the traffic statistics associated with the selected packet flows.

Claim 2 (Currently Amended) The method of claim 1, ~~further comprising:~~ wherin processing the heap to select one or more of the packet flows comprises:
receiving a query from a client;
processing the heap in response to the query to select one or more of the nodes of the tree while continuing to update the traffic flow statistics in the flow table in response to network traffic; and
outputting the traffic statistics associated with the selected nodes of the tree packets to the client.

Application Number 10/670,944
Response to Office Action mailed January 10, 2008

Claim 3 (Currently Amended) The method of claim 1, wherein processing the heap comprises:

cloning the heap to produce a heap clone in the form of a tree having a root node and a plurality of other nodes arranged as parent nodes and child nodes, the nodes of the heap clone storing copies of the traffic statistics stored by the nodes of the heap; and

extracting one or more nodes heap-entries from the heap clone to select the packet flows.

Claim 4 (Original) The method of claim 1, wherein calculating traffic statistics and maintaining a heap are performed concurrently with processing the heap and outputting the traffic statistics.

Claim 5 (Currently Amended) The method of claim 1, wherein ~~calculating traffic statistics comprises maintaining a flow table that stores traffic flow statistics for a set of packet flows~~ maintaining a heap comprises maintaining the heap in real-time to reflect changes to the traffic statistics within flow table.

Claim 6 (Original) The method of claim 1, wherein maintaining a heap comprises maintaining a table representation of the heap.

Claim 7 (Original) The method of claim 6, wherein maintaining the heap comprises storing packet flow identifiers as elements of the table and in a heap-ordered fashion.

Claim 8 (Original) The method of claim 1, further comprising identifying the packet flows by at least one of a source network address, a destination network address, a protocol, a source port number, and a destination port number.

Application Number 10/670,944
Response to Office Action mailed January 10, 2008

Claim 9 (Original) The method of claim 1, wherein calculating traffic statistics comprises:
receiving a packet from a network via an interface card of a network device; and
extracting a key from the packet;
associating the packet with one of the packet flows based on the key; and
updating the flow statistics for the associated packet flow based on contents of the packet.

Claim 10 (Original) The method of claim 9, wherein maintaining a heap comprises performing a heapify operation on the heap after receiving the packet and updating the flow statistics.

Claim 11 (Original) The method of claim 1, wherein calculating traffic statistics further comprises communicating the packets to an accounting service card of a network device, wherein the accounting service card calculates the traffic statistics.

Claim 12 (Original) The method of claim 1, further comprising:
receiving a query from a network client, wherein the query requests M-ordered packet flows;
cloning the heap to produce a heap clone in response to the query
performing M-1 heapify operations to extract the M ordered packet flow identifiers from the heap; and
outputting the traffic statistics associated with the M packet flow identifiers.

Application Number 10/670,944
Response to Office Action mailed January 10, 2008

Claim 13 (Currently Amended) A method comprising:

maintaining a heap that provides a heap-ordered representation of packet flows within a network based on at least one criteria associated with the packet flows, the heap-ordered representation of packet flows comprising is a tree having a root node and a plurality of other nodes arranged as parent nodes and child nodes, each of the nodes storing traffic statistics for a different one of the packet flows, and wherein a value for the traffic statistics stored in any child node is less than or equal to a value for the traffic statistics stored for its parent node within the tree; and

processing the heap to output traffic statistics associated with an ordered subset of the packet flows.

Claim 14 (Original) The method of claim 13, wherein the criteria comprises one of a byte count and a packet count associated with each of the packet flows.

Claim 15 (Original) The method of claim 13, wherein processing the heap comprises:

receiving a query from a network client;

cloning the heap to produce a heap clone;

extracting one or more heap entries from the heap clone to extract identifiers for the ordered subset of the packet flows; and

outputting the traffic statistics associated with the extracted identifiers.

Claim 16 (Original) The method of claim 13, wherein maintaining a heap is performed concurrently with processing the heap.

Application Number 10/670,944
Response to Office Action mailed January 10, 2008

Claim 17 (Withdrawn) A method comprising:

maintaining a data structure that stores N packet flow identifiers for packet flows within a network;

receiving a query from a network client, wherein the query requests traffic flow statistics for M packet flows selected from the N packet flows based on an ordered relationship to a criteria;

applying an algorithm to process the data structure to identify the M packet flows in a computational time that can be represented as less than or equal to $O(M\log(N))$; and

outputting the traffic statistics associated with the M packet flows.

Claim 18 (Withdrawn) The method of claim 17, wherein the criteria comprises one of a byte count and a packet count associated with each of the packet flows.

Claim 19 (Withdrawn) The method of claim 17, wherein the data structure comprises a heap that provides a heap-ordered representation of the packet flows.

Claim 20 (Withdrawn) The method of claim 19, wherein applying an algorithm comprises:

cloning the heap to produce a heap clone;

extracting one or more heap entries from the heap clone to extract packet flow identifiers for the M packet flows; and

outputting the traffic statistics associated with the extracted identifiers.

Claim 21 (Original) A computer-readable medium comprising instructions for causing a programmable processor to:

calculate traffic statistics associated with packet flows through a network;

maintain a heap that provides a heap-ordered representation of the packet flows;

process the heap to select one or more of the packet flows; and

output the traffic statistics associated with the selected packet flows.

Application Number 10/670,944
Response to Office Action mailed January 10, 2008

Claim 22 (Original) The computer-readable medium of claim 21, further comprising instructions to cause the processor to:

- receive a query from a network client;
- process the heap in response to the query; and
- output the traffic statistics associated with the selected packets to the network client.

Claim 23 (Original) The computer-readable medium of claim 21, wherein the instructions cause the processor to:

- clone the heap to produce a heap clone; and
- extract one or more heap entries from the heap clone to select the packet flows.

Claim 24 (Original) The computer-readable medium of claim 21, wherein the instructions cause the processor to perform calculating traffic statistics and maintaining a heap concurrently with processing the heap and outputting the traffic statistics.

Claim 25 (Original) The computer-readable medium of claim 21, wherein the instructions cause the processor to maintain a flow table that stores traffic flow statistics for a set of packet flows.

Claim 26 (Original) The computer-readable medium of claim 21, wherein the instructions cause the processor to maintain a table representation of the heap.

Claim 27 (Original) The computer-readable medium of claim 21, wherein the instructions cause the processor to store packet flow identifiers with the heap in a heap-ordered fashion.

Application Number 10/670,944
Response to Office Action mailed January 10, 2008

Claim 28 (Currently Amended) Network elements comprising:

an interface to receive packets flows from a network; and
a control unit coupled to the interface,

wherein the control unit computes flow statistics for the packets, and maintains identifiers for the packet flows in a heap-ordered representation based on at least one of the statistics, wherein the heap-ordered representation is a tree having a root node and a plurality of other nodes arranged as parent nodes and child nodes, each of the nodes storing traffic statistics for a different one of the packet flows, and wherein the tree is heap-ordered in that a value for the traffic statistics stored in any child node of the tree is less than or equal to a value for the traffic statistics stored within that child node's parent node within the tree.

Claim 29 (Original) The network elements of claim 28, wherein the control unit maintains the identifiers as a heap having a plurality of entries, wherein each entry stores a respective identifier for one of the packet flows.

Claim 30 (Original) The network elements of claim 29, further comprising a user interface to receive a query from a client, wherein the control unit processes the heap in response to the query to select one or more of the identifiers, and the user interface outputs a portion of the traffic statistics associated with the selected identifiers.

Claim 31 (Original) The network elements of claim 29, wherein the control unit clones the heap to produce a heap clone, and processes the heap clone to extracting the identifiers.

Claim 32 (Original) The network elements of claim 29, wherein the control unit concurrently computes the flow statistics and maintains the identifiers concurrently with processing the heap and outputting the portion of the traffic statistics.

Application Number 10/670,944
Response to Office Action mailed January 10, 2008

Claim 33 (Original) The network elements of claim 29, wherein the control unit associates the packets with the packet flows by determining for each packet at least one of a source network address, a destination network address, a protocol, a source port number, and a destination port number.

Claim 34 (Original) The network elements of claim 28, wherein the control unit calculates the flow statistics and maintains the heap-ordered representation in real-time as packets are received from the interface card.

Claim 35 (Original) The network elements of claim 28, wherein the control unit comprises an accounting module that calculates the traffic statistics.

Claim 36 (Original) The network elements of claim 28, further comprising an accounting service card, wherein the control unit forwards the packets to the accounting service card to calculate the traffic statistics.

Claim 37 (Original) The network elements of claim 28, wherein the control unit comprises: a routing engine to maintain routing information representing a topology of the network; and a forwarding engine to forward the network packets in accordance with the routing information.

Claim 38 (Original) The network elements of claim 28, wherein the network device comprises one of a router, a switch, a gateway, and a hub.

Claim 39 (Original) A network device comprising:
an interface to receive packets flows from a network;
a control unit coupled to the interface; and
an accounting service card, wherein the control unit forwards the packets to the accounting service card to calculate the traffic statistics, wherein the accounting service card computes flow statistics for the packets, and maintains maintaining a heap that provides a heap-ordered representation of the packet flows.

Application Number 10/670,944
Response to Office Action mailed January 10, 2008

Claim 40 (Original) The network device of claim 39, wherein the accounting service card comprises:

- a flow table to store the flow statistics; and
- a heap table to store the heap.